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PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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INVENTOR(S)

Given Name (first and middle [if any])	Family Name or Surname	Residence (City and either State or Foreign Country)
Terry P.	Bowen	Middletown, Pennsylvania, U.S.A.
Richard J.	Perko	Middletown, Pennsylvania, U.S.A.
John B.	Breedis	Middletown, Pennsylvania, U.S.A.

☐ *Additional inventors are being named on the _____ separately numbered sheets attached hereto*

TITLE OF THE INVENTION (280 characters max)

MODULAR HYBRID OPTOELECTRONIC ASSEMBLY

CORRESPONDENCE ADDRESS

Direct all correspondence to:

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Type Customer Number here

OR

☒ Firm *or* Individual Name	The Whitaker Corporation				
Address	4550 New Linden Hill Road				
Address	Suite 450				
City	Wilmington	State	Delaware	ZIP	19808
Country	U.S.A.	Telephone	(302) 633-3568	Fax	(302) 633-2776

ENCLOSED APPLICATION PARTS *(check all that apply)*

☒ Specification *Number of Pages* 11
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☐ Application Data Sheet. See 37 CFR 1.76
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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No.
☐ Yes, the name of the U.S. Government agency and the Government contract number are: ______________

Respectfully submitted,

SIGNATURE [signature]

Date 07/03/2002

TYPED or PRINTED NAME Stephen J. Driscoll

REGISTRATION NO. *(if appropriate)* 37,564

TELEPHONE (302) 633-3568

Docket Number: 17885L

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

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Invention: MODULAR HYBRID OPTOELECTRONIC ASSEMBLY			

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TRUE POSITION BENCH

FIELD OF INVENTION

This invention relates generally to an optical package, and, more specifically, to an optical package having an alignment member for optically aligning its components.

BACKGROUND

The use of optical fibers as a medium for transmission of digital data (including voice) is becoming increasingly more common due to the high reliability and large bandwidth available with optical transmission systems. The construction of optical packages for transmitting/receiving optical signals and multiplexing/demultiplexing signals, however, is difficult, expensive, and time consuming.

One of the primary technical challenges associated with the manufacture of optical systems, and especially systems offering higher levels of integration, is component alignment. This is especially applicable in free-space-interconnect optical systems where optical components, such as active device (e.g., semiconductor lasers), passive devices (e.g., filters), and/or MOEMS (micro-optical electromechanical systems) (e.g., tunable filters and switches) are integrated together on a common mounting system.

Optical mounting systems, sometimes referred to as "optical benches," provide a rail or platform to facilitate the mounting of various optical elements and focal planes in fixed relationship with each other for various applications. Scales characteristic of such optical components can necessitate sub-ten micrometer to sub-micrometer alignment accuracy. Therefore, the mounting and alignment of the optical components must be performed to exacting tolerances.

There are two general classes of alignment strategies: active and passive. Typically, in passive alignment of the optical components, registration or alignment features are fabricated directly on the components as well as on the platform to which the components are to be mounted. The components are then mounted and bonded directly to the platform using the alignment features. In active alignment, an optical signal is transmitted through the components and detected, sometimes after an initial passive alignment of the components. The alignment is performed based on the transmission characteristics to enable the highest possible performance level for the system.

Generally, optical system manufacturing systems seek to improve the speed at which the optical systems can be manufactured using passive alignment. In the ideal case, the optical systems can be manufactured using all passive alignment strategies, but even if an all-passive alignment approach is not possible requiring a subsequent active alignment "tuning or optimization step," the precision of the passive alignment is critical to minimizing the time required in the final active alignment.

Therefore, a need exists for an optical mounting platform which eliminates or reduces the need for active alignment but which is acuate to submicron precision. The present invention fulfills this need among others.

SUMMARY OF INVENTION

The present invention provides for a true position bench (herein "TPB") that is capable of not only aligning optical components within sub-micron tolerances, but also lends itself to passive alignment. Specifically, the TPB of the present invention employs a substrate having a V-groove which ensures passive xy alignment among the optical components mounted within the V-groove. Although V-grooves are well known in the art for aligning fibers (or other round components) to optical components mounted to the substrate, the present invention uses the V-groove to align base type optical components (i.e., non-circular cross section) devices such as semiconductors. To this end, the present invention provides for some special side features of the

base-type optical components to allow them to mount reliably within the V-groove such that their optical axis is positioned along the main optical axis of the TPB.

One aspect of the invention is an optical assembly comprising a substrate with a V-groove in which the optical components (including base-type optical components) are mounted. In a preferred embodiment, the optical assembly comprises (a) a substrate having a top surface and defining a V-groove in the top surface, the V-groove having walls of a certain pitch; (b) a first optical component disposed in the V-groove, the first optical component having a reference surface and two sides, each side being beveled at the certain pitch outwardly from the reference surface, the first optical component having a first optical axis a certain distance from the reference surface, the first optical component being disposed in the V-groove such that the reference surface faces downward with respect to the top surface and the sides are in parallel contact with the walls of the V-groove and the first optical axis is positioned along a main optical axis within the V-groove; (c) a second optical component disposed in the V-groove, the second optical component having an outer periphery with at least two contact points and a second optical axis, the second optical component being disposed in the V-groove such that the contact points contact the walls of the V-groove and the second optical axis is positioned along the main optical axis.

Another aspect of the invention is a method of manufacturing the first optical component for use in the optical assembly described above. In a preferred embodiment, the method comprises: (a) etching at least two parallel V-grooves in a wafer to define a center section and two side sections; and (b) detaching the two side sections from the center section along the parallel V-grooves to leave a base having two parallel sides, each side comprising a portion of one of the two V-grooves. At this point, the base may be further processed to form an active or passive device. Preferably, the wafer is used to produce a number of bases. According, in a preferred embodiment, there are more than two parallel V-grooves formed in the wafer and the side portions mentioned above are also formed into bases. In yet another preferred embodiment, the first optical component is an opto-electric component. In such an embodiment, it is

preferable that solder pads (for receiving an opto-electric device) be defined on the base during the same photolithography step as the parallel V-grooves are defined.

The TPB of the present invention and its manufacture have a number of important advantages over the prior art. First, since the V-groove has both x and y-axis components to its surfaces, it provides for both x and y axis alignment. This is a significant advantage over prior art optical benches, such as platforms and rails, which may provide alinement along either the x or y axis, but not both.

Not only does the TPB of the present invention provide for xy alignment, but the alignment that it provides is particularly robust. That is, since the optical components are mounted to a common surface, the TPB is more tolerant of environment changes and manufacturing tolerances. For example, if the TPB is exposed to significant temperature swings, the effect of dimensional variations of the TPB will be mitigated since all of the optical components are mounted on the same surface. In other words, any changes will affect all the components equally. Additionally, if the V-groove is subject to manufacturing variations, the inter-component effects will again be minimized since all the components will be affected similarly. For example, if the V-groove is etched more narrowly, the optical components will all seat higher relative to the bottom of the V-groove.

Yet another advantage of the TPB of the present invention is the precision it affords. Specifically, techniques have been developed for forming V-grooves in substrates to exacting tolerances. This is significant not only with respect to the main V-groove, but also with respect to the first optical component. Specifically, the base of the first optical component is preferably formed by etching parallel V-grooves into a wafer and then parting the wafer along the V-grooves to leave the base. Thus, the dimensions of the substrate are defined using V-grooves which, as mentioned above, are extremely accurate.

In addition to a high degree of dimensional accuracy, the preparation technique of the present invention also allows for extremely accurate positioning of an opto-electric device on the base of the first optical component. Specifically, the V-grooves and the solder pads for the opto-

electric device can be located on the wafer in one step using well-known photolithography techniques. The ability to do both at the same time is important since the distance from the optical axis of the opto-electric device and the sides of the base are critical. Defining the solder pads in effect defines the position of the opto-electric device on the substrate since the surface tension of the solder pads will tend to pull the device over them during reflow. This is a well-known technique. Thus, the preparation technique of the present invention not only defines the dimensions of the base accurately using V-groove techniques, but also defines the position of the solder pads (and thus the optoelectric device) precisely with respect to the sides of the base. (Although the present invention realizes certain advantages over prior art techniques in manufacturing an opto-electric first optical component, it should be understood that the invention is not limited to an opto-electric first optical component.)

BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a cross-sectional view of a preferred embodiment of the true position bench of the presnent invention.

DETAILED DESCRIPTION

Referring to Fig. 1 a preferred embodiment of the true position bench (TPB) 1 of the present invention is shown. The TPB comprises (a) a substrate 2 having a top surface 14 and defining a V-groove 3 in the top surface 14, the V-groove having walls 3a, 3b of a certain pitch α; (b) a first optical component 4 disposed in the V-groove 3, the first optical component 4 having a reference surface 15 and two sides 6a, 6b, each side being beveled at the certain pitch α outwardly from the reference surface 15, the first optical component 4 having a first optical axis 10a a first distance from the reference surface 15 and a second distance from each of the two sides 6a, 6b, the first optical component 4 being disposed in the V-groove 3 such that the reference surface 15 faces downward with respect to the top surface 14 and the sides 6a, 6b are in parallel contact with the walls 3a, 3b, respectively, of the V-groove 3 and the first optical axis 10a is positioned along a main optical axis 10 within the V-groove 3; (c) a second optical component 11 disposed in the V-groove 3, the second optical component having an outer

periphery 13 with at least two contact points 13a, 13b and a second optical axis 10b a third distance from each of the contact points 13a, 13b, the second optical component 11 being disposed in the V-groove such that the contact points 13a, 13b contact the walls 3a, 3b of the V-groove 3 and the second optical axis 10b is positioned along the main optical axis 10. Each of these elements is described in greater detail below.

__Substrate__

The substrate 2 serves as the main foundation for the TPB. To this end, it must comprise a rigid material which can be etched using either dry or wet etching techniques. Examples of suitable materials include semiconductor materials (such as silicon), ceramics, quartz, and metal. Preferably, the substrate 2 comprises silicon given the material's ability to be etched predictably using wet etching techniques. Wet etching is preferred from a cost effectiveness and accuracy standpoint. That is, wet etching techniques are well known and can be performed on a large-scale basis more readily than dry etching.

The V-groove formed in the substrate 2 has a particular pitch α. The term "pitch," as used herein, refers to the angle between the V-groove wall and the perpendicular from the surface in which the V-groove was etched. The pitch of a V-groove depends upon the etching technique used and the material being etched. For example, due to the crystalline structure of silicon, a predictable and highly precise pitch α can be realized in a V-groove wet etched in silicon.

The dimension of the V-groove of the TPB of the present invention is larger than those typically used in optical subassemblies. More specifically, V-grooves have been used traditionally to receive components having a relatively small circular cross section, such as a fiber. Further, the optical axis of the component with respect to the V-groove was typically near or above the substrate surface. In the TPB of the present invention, however, the V-groove is adapted to receive much larger components relatively speaking, such as a ferrule or semiconductor device, and the optical axis is preferably below the top surface. To accommodate the relatively large optical components such that their optical axis is below the top surface of the substrate 2, the V-groove must be relatively large. For example, in the embodiment shown in

Figure 1, the V-groove is wider at the top surface 14 than the second optical component 11 is in diameter. If the second optical component in this depicted embodiment is an LC-type ferrule, the V-groove at the top surface must be larger than 1250 microns. Due to the relatively large size of the V-groove 3, it may be preferable to truncate the V-groove so as not to have an overly thick substrate 2. Such an embodiment is shown in Figure 1.

First Optical Component

The first optical component is a base type optical component. As used herein, the term "base-type component" refers to components which do not have a circular cross section (e.g., fibers and ferrules), but instead have a base upon which the devices or wave guides are mounted. Examples of base-type optical components include (a) passive devices, such as, add/drop filters, arrayed wave guide gratings (AWGs), GRIN lens, splitters/couplers, planar waveguides, or attenuators, and (b) active devices, such as, lasers (e.g., vertical cavity surface emitting laser (VCSEL), double channel, planar buried heterostructure (DC-PBH), buried crescent (BC), distributed feedback (DFB), distributed bragg reflector (DBR), etc.), light-emitting diodes (LEDs) (e.g., surface emitting LED (SLED), edge emitting LED (ELED), super luminescent diode (SLD), etc.) or photodiodes (e.g., P Intrinsic N (PIN), avalanche photodiode (APD), etc.). Preferably, the first optical component is a semiconductor component such as a laser.

The first optical component 4 comprises a base 5 which has sides 6a and 6b which are beveled with respect to the reference surface 15. It is critical that the sides are beveled with same pitch as the V-groove so that the sides contact the walls of the V-groove in a parallel arrangement. As mentioned above, the pitch will depend upon the etching technique used and the substrate material. Therefore, it is preferable, although not necessary that the substrate 2 and the base 5 comprise a similar material. In a preferred embodiment, the base 5 is silicon.

The first optical component has a first optical axis 10a, which is typically near the reference surface 15. As shown in figure 1, the first optical axis 10a is a first distance from the reference surface 15 and a second distance from each of the two sides 6a, 6b. These are critical

dimensions and affect the location of the first optical path 10a when the first optical component is mounted in the TPB 1. In a preferred embodiment, there is just one optical axis which is equidistant between sides 6a and 6b. However, it should be understood, that the present invention is not limited to optical components having a single optical axis. In an embodiment having multiple optical axes, a given optical axis may be asymmetrical with respect to sides 6a and 6b.

The TPB of the present invention facilitates economical and highly repeatable manufacturing of the first optical component. Specifically, the base 5 can be prepared *en mass* from a wafer by etching a series of parallel V-grooves into the wafer. The wafer section between any two adjacent parallel V-grooves defines the base. In other words, the beveled sides 6a, 6b, as shown in Figure 1, are preferably one half of the V-grooves etched in the silicone wafer. The wafer is simply parted at each V-groove to form an edges 7a, 7b.

Preferably the first optical component is an optoelectric component having an optoelectric device 9 mounted to the base 5. The present invention is particularly well suited for the manufacture of such a component since all of the critical dimensions may be defined in a single photolithography step. That is, during the step in which the V-grooves are defined in the silicon wafer (which, as mentioned above, define sides 6a and 6b) solder pads may be defined on the base 5 too. The solder pads serve to align the optoelectric device 9 during reflow through surface tension. This is a known technique and will not be discussed in detail herein. Thus, the critical distance of the optical path 10a from sides 6a and 6b can effectively be accomplished in a single step, thereby eliminating tolerance build up and simplifying manufacturing.

<u>**Second Optical Component**</u>

The second optical component may be a base type component (just like the first optical component described above) or it may be an optical component having a circular cross section. Examples of optical components having circular cross sections include fibers, lenses (e.g., ball lenses), ferrules or any other type of component that has traditionally been used in combination

with the V-groove. As shown in Figure 1, the first optical component is a ferrule containing a fiber 12 and having an optical axis 10b.

The second optical component has a periphery 13 that has two points 13a and 13b that contact with the V-groove when the second optical component is disposed in the V-groove 3. It should be understood, that if the second optical component is a base-type optical component then the points 13a and 13b would be found on its beveled sides as described above with respect to the first optical component.

The second optical component has a second optical axis which is a certain distance from points 13a and 13b. In a single optical axis configuration, this distance is preferably the same, however, if the TPB is a multiple optical axis device, then it is likely that each optical axis will not be symmetrically positioned between points 13a and 13b.

Although only two optical components are considered herein, it should be understood that a single TPB of the present invention may be populated with a multiplicity of first and second optical components as described above.

What is claimed is:

1. An optical package comprising:

a substrate having a top surface and defining a V-groove in said top surface, said V-groove having walls of a certain pitch;

at least a first and second optical component disposed in said first V-groove;

said first optical component having a reference surface and two sides, each side being beveled at said certain pitch outwardly from said reference surface, said first optical component having an first optical axis a certain distance from said reference surface, said first optical component being disposed in said V-groove such that said reference surface faces downward with respect to said top surface and said sides are in parallel contact with the walls of said V-groove and said first optical axis is positioned along a main optical axis within said V-groove;

said second optical component having an outer periphery with at least two contact points and a second optical axis, said second optical component being disposed in said V-groove such that said contact points contact said walls of said V-groove and said second optical axis is positioned along said main optical axis.

2. The optical package of claim 1, wherein said V-groove is prepared by wet etching.

3. The optical package of claim 1, wherein said first optical component is a semiconductor.

4. The optical package of claim 3, wherein said semiconductor is an active device.

5. The optical package of claim 1, wherein said first optical component is a passive device.

6. The optical package of claim 1, wherein said second optical component is a ferrule.

7. The optical package of claim 1, wherein said second optical component is a semiconductor having a reference surface and beveled sides and said two contact points are located on said beveled sides.

8. The optical package of claim 1, wherein said main optical axis is below said top surface.

9. The optical package of claim 1, wherein the distance across said V-groove at said top surface is greater than the distance across said second optical component.

10. The optical package of claim 1, wherein each side is a portion of a V-groove.

11. A method of preparing a first optical component for incorporation into an optical subassembly as defined in claim 1, said method comprising:

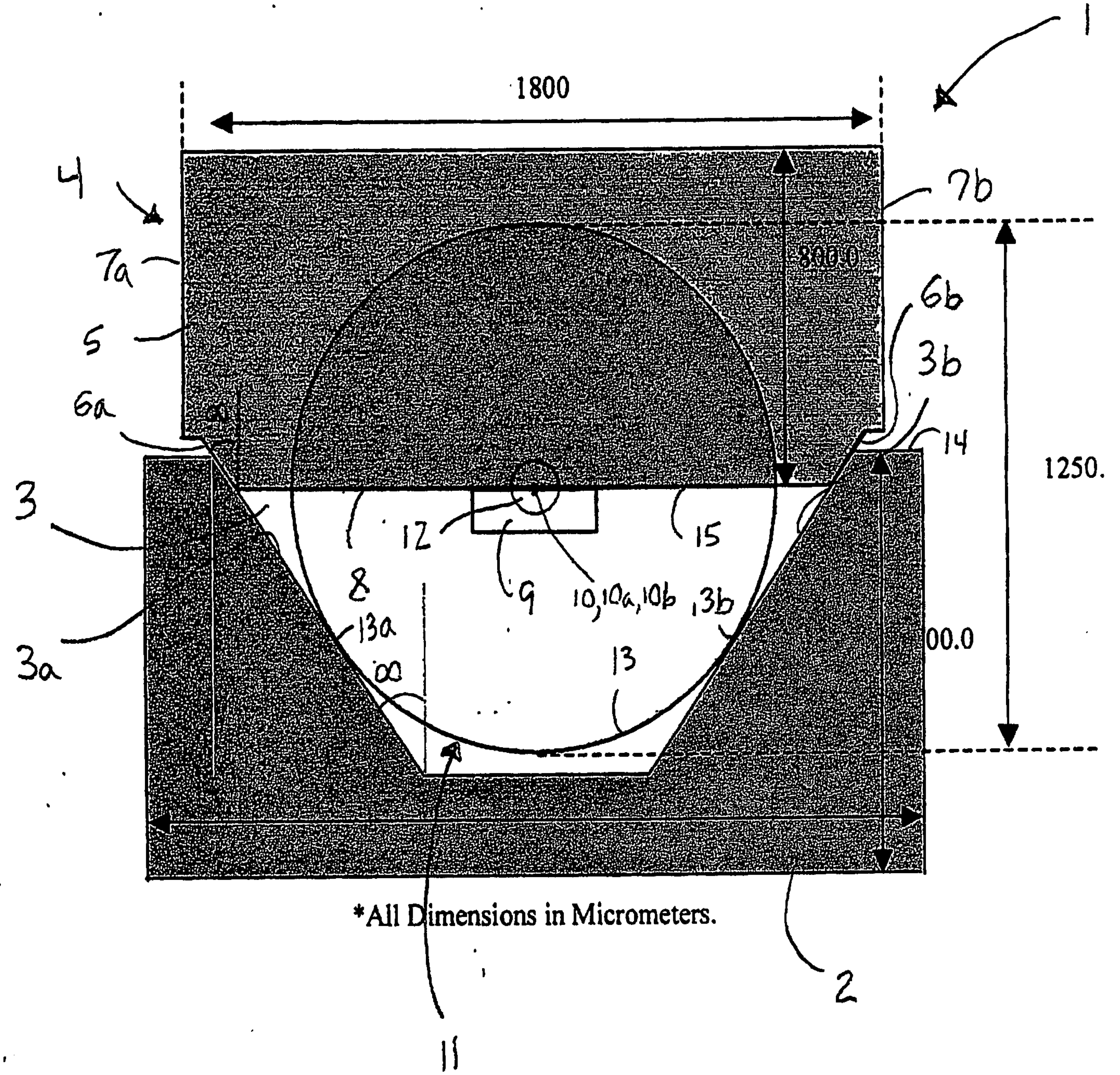
etching two parallel V-grooves in a wafer to form a center section and two side sections;

detaching said two side sections from said center section along said parallel V-grooves to leave a base in which each of its sides comprise a portion of a parallel V-groove;

incorporating either an active or passive device on said base to form said first optical component.

12. The method of claim 11, wherein said side sections are other bases.

13. The method of claim 11, further comprising defining the placement of said parallel V-grooves and solder pads in a single photolithography step.



*All Dimensions in Micrometers.

Fig 1